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Edward Mackey Johnson

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Department: Materials Science and Engineering

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THESIS

ALUMINIUM

JOHNSON

1892

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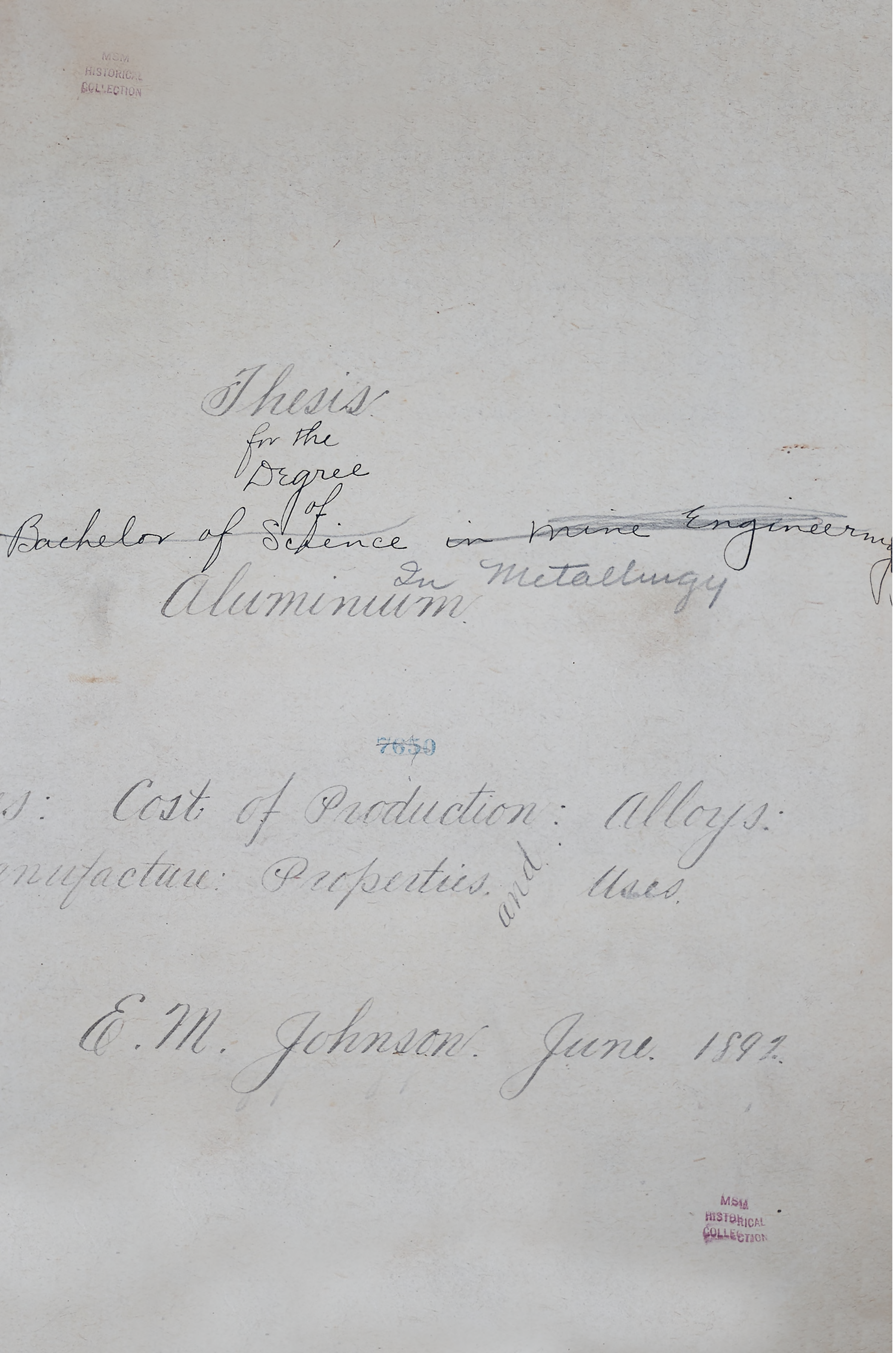
MSM
HISTORICAL
COLLECTION

Thesis
for the
Degree
of
~~Bachelor of Science in Mine Engineering~~
In Metallurgy
Aluminium

7650

s: Cost of Production: Alloys:
nufacture: Properties, and Uses.

E. M. Johnson. June 1892.

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Aluminum

Ores: Cost of Production: Alloys:

Manufacture, Properties, and Uses

E. M. Johnson: June 1892

Thesis.

Aluminium. June 1892.

Ores: Cost of Production: Alloys.

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It is not the purpose of this thesis to discuss all the ores in which Al. is found, but to describe rather fully the ores from which Al. is obtained: such as Bauxite and cryolite.

In regard to the alloys only the principal ones will be considered and described: especially the Al-bronze which is a very important alloy of copper and Al.

Ores:

Al. has never been found in the metallic state, though it occurs more widely distributed and abundant than any other metal.

It is found in many precious stones, such as Ruby, Sapphire, and Garnet.

It also occurs in combination with silicon, and other bases, and is a principal constituent of clay.

Corundum contains about 93% Al_2O_3, but as it is very hard and crystalline and more suitable for other appliances, as the manufacture of emery, that it has not yet been used to obtain Al. from

Diaspore contains from 64 to 75% Al.

Thesis

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It is similar to corundum, being hard and crystalline. many other minerals might be enumerated in which Al. occurred but not applicable to its production. The following minerals are at present considered as the ch source of Al. namely Bauxite. and cryolite.

Bauxite: $Al_2(HO)_6$: It was found in France in the town of Beau. in lay deposits: also in Austria. Slyria, and Ireland. In U.S. it is found in abundance in Tenn. Va. north. and South Carolina. Georgia. Alabama and Ark. Bauxite is soft. and granular and sometimes contains a few im-purities besides the water of hydratio It generally contains from 50 to 70% of Alumina (Al_2O_3). in combination with Iron. Silica. Potassium. and Sodium. The price paid for Bauxite varies from \$6.00 to \$10.00 per ton de-pending upon its purity.
Cryolite: $6NaF+AlF_6$: Contains 13% Al. It is a semitransparent snow white mineral. If impure it has a yellow or red color. Its Sp. Gr. is 2.9 hards

II

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Cryolite: $6NaF+AlF_6$: contains 13% Al. It is a semitransparent snow white mineral. If impure it has a yellow or red color. Its Sp. Gr. is 2.9 hardness

2.5. It fuses on the edges in the
flame of a candle, and heated in
an open tube gives off fluorine.
The principle source of cryolite is
a bay in Arksut-fiord in west Green-
land at Evigtok, where it constitutes
a large bed or vein in gneiss.
The mine is worked as a quarry
and has been opened 450 ft. long
150 ft. wide and 100 ft deep. while dia-
mond drills have penetrated much
farther. and found it. The cryolite
imported from this place, sells in
barrel lots in N.Y. at 7 cts. per lb.
or in ton lots at $125 per ton.
The only place in the U.S. where
cryolite is found. is near Pikes
Peak Col. occuring in small masses
in quartz. and fedspar veins. in a
country rocks of coarse reddish granite
but no quantity of any consequence
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place. Cryolite is also used for making
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The introduction of cryolite for the
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but it has its disadvantages: as the
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are attacked and the Al. obtained
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Alloys.

The properties of Al. alloys. like other
alloys depends upon the proportion of
the metals united. and as there is
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criptions. Hence as already stated it
is only the intention of this paper
consider the most important alloys.
Especially Al. Bronze. a very importan
alloy of Copper and Al.
Al. unites easily with most metals.
usally with the evolution of heat.
Lead. Antimony. and mercury being
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and are generally improved by remelting.
The useful alloys of Al are divided

into two groups. (1) Al. not containing
not over 10 to 15% of other metals.
(2) Other metals containing not over
10 to 15% Al. Alloys not falling
under these two heads posses no
useful properties. and are considered
as mere chemical curiosities.
Many of these alloys are easily worked
and possess special properties: such as
resistence to Corrosion. hardness
pleasant color. and tenacity. Gold
Silver. and Tin do not impair the
malleability of Al. but even small
amounts of Iron. and Silica. are
very injurious.
The alloys of nickel. and Al. are
not very important. but an alloy
of 63% Copper 33% nickel and 3% Al.
forms an alloy of good tensile strength
and suitable for the manufacture of
table knifves. The introduction of
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V

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it better for casting as it fills the
mould better and shrinks less.
Al with 5% silver has been used
for dessert spoons, knife blades and
even for watch springs. This alloy
has also been suggested for as a
substitute for coin silver.
With 10% silver it forms an alloy
which can be stamped and engraved
with greater ease than
the alloys of silver and copper.
Articles generally made of silver are
now made with this alloy.
A small % of Al added to gold
takes away nearly all of its malleability.
10% Al makes a white
brittle alloy. 5% makes it as brittle
as glass. 1% gives an alloy similar
to the alloy called by the jewelers
“green gold.” An alloy of 90% copper
2 ½% gold and 7½ % Al resembles gold
in color, does not tarnish, and is
used to make cheap imitation
gold ware. An alloy of Al with 9%
tin is recommended for the inner
parts of optical instruments instead

of brass. The principle objection to some of the tin alloys is that the Al. and tin separate when remelted.
Zinc, and Al. unite readily. The alloy is generally harder, and more fusible than Al. some very good soldering has been done with this alloy. but does not answer very well: as they become thick when melted.
The addition of copper increases the value of this alloy. forming what are called Al-brasses. and they are as much superior to the ordinary brass. as Al-bronze is to ordinary bronze.
A small amount of silicon does not impair the malleability of Al. but over one or two % commences to change its color, make it harder and more crystalline. so that its malleability is rapidly impaired. Silicon acts with Al. very similar as carbon does with Iron.
The alloys of iron, and Al. are very interesting. A small amount of iron renders the Al. very brittle, hard, and crystalline: but a small proportion of Al. imparts valuable properties to Al

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Iron, and steel. The effects being different upon wrought, and cast iron.

Al-Copper Alloys:

These two metals unite readily in all proportions. but the important alloys may be classed under the following two heads.

(1) Those in which a small % of copper imparts valuable properties to the Al.

(2) Those in which a small % Al imparts valuable properties to the copper. The last is the most important industrially. A small proportion of copper increases the hardness. With 3% copper the metal is whiter, and more easily worked than Al. With 5% copper the alloy is about as hard as standard silver 30 to 40% Copper makes the alloy very brittle, hard, and crystalline. Alloys containing 10% or less of Al. are very valuable; as they are hard tenacious and easily worked. Al-bronze containing 10% Al. is the most important of the

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alloys. Pure copper, and Al. must
be used to produce it. The Al-bronze
is of a bright gold color. Sp. Gr. about
the same as wrought iron. It takes
a fine polish, and casts well.
It is less acted upon by vegetable
acids, and other ordinary reagents
than other alloys of copper.
It is malleable at all temperatures.
Tensile strength equals that of good
steel. As regards it resistive pressure
it stands between iron and steel.
Al-bronze may be applied to an
immense variety of purposes on
account of its lightness and beauty.
Its universal application only being
retarded by its high price, which
will probably decrease in a few years.
It will most likely be used as
ordinary tin bronze, or even brass
itself. No one can imagine the
changes that will probably be caused
by the introduction of this new, and
wonderful white metal. We have
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Cost of Production:
Through the gradual reduction of
sodium, and finally by the introduc
of the Electric Dynamo, the price of
Al. was reduced $90 per. lb. in 1855
to $5.00 per. lb. in 1887. Two years la
the Pittsburg reduction company
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selling. it below cost. So the price
again increased until it reached
75¢ which is about the present
cost. and the future reduction of
this price depends almost entirely
upon the increased application
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E. M. Johnson.
Mo. School of Mines.
Rolla
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Manufacture.

Al. is now only made by processes of electrodeposition from fused electrolytes. In this country, the Pittsburg Reduction Co. and the Cowles Electric Smelting and Al. company, are the only places manufacturing, and furnishing the American market with Al.

In Great Britain, the Metal Reduction Syndicate Limited, a branch of the Pittsburg Reduction Co. and Switzerland, the Al. Industrie Actien Gesellshaft, using water power of the falls of the Rhine, and in France the firm of Bernard Bro's. now building works at St. Miachael, and operating the minet process.

The sodium process of making Al. is now considered a thing of the past. after reaching what was considered its highest stage of development.

Men have long directed their attention to the electro mettallurgical process of extracting Al. and so active has the work been; that this process has about reached its culmination point and men are now racking their brains

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The four more or less similar processes now in use are: the Cowles Heroult, Hall, and Minet.

In the Cowles process the Al. compound is reduced in the presence of carbon in a furnace heated by electricity: the alloy of Al. and the metal formed being further treated to separate out the Al. The company is also now preparing the pure Al. directly.

In the Heroult process for the production of pure Al. a mixture of cryolite, and alumina is fused in a carbon crucible contained in one of plumbago, and set in a wind furnace. The inner crucible serves as a cathode of an electric current. By using a current of 3 volts electromotive morce the alumina is electrolyzed, Al. being deposited on the walls of the crucible and a corresponding amt. of O set free at the carbon anode, which is gradually consumed. The bath must be replenished

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of Al. fluoride. and potassium fluoride.
then electrolyzing this bath. using
an anode of non carbonaceous material
The principle of the processes is about
the same in all cases. only varying
in details i.e. the decomposition of
some compound of Al. by electricity.
With the aid of Mr McRae. Messrs
D.C. Jackling. H. J. Jones. and myself
tried to make some pure Al. at the
Mo. School of Mines. using a dynamo.
run by a five horse power engine.
We used a common hessian crucible.
with a hole through the bottom also
one through the cover. the carbon
poles being luted to the bottom. and
top by means of Kaolin. we then
charged the crucible with pure cryolite.
~~connected~~ completed the circuit
with the dynamo. and ran for one
hour: with 90 to 100 volts. and 15 to 20
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XIV

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the want of conveniences our work
was not crowned with success.
Although we did obtain ~~by~~ rather
discover by several processes of grinding
and washing and finally by the
aid of the microscope, several pieces
of what we supposed to be Al but
we did not have enough to verify
by tests. This attempt nearly discouraged
us but I thought I would try it again
more for the novelty than for any
idea of supplying the market.
This time instead of using the
crucible I bored a hole an inch in
diameter into a large carbon pole
and filling this cavity with cryolite
connecting one wire of the dynamo
directly with this carbon pole and
using a small carbon pole to introduce
into the cryolite. The rest of
the process was the same as before.
The chief objection to this method
~~being~~ was that I could not get the
heat concentrated in one place all
the time. Neverless owing to some
improvement or other, I succeeded in

btaining the Al. in little globules
not having to use the microscope
to find it. The work was not so
instructive as to the process of making
~~of~~ Al. but we learnt many little details
in the course of the operations.
Properties:-
Al. is no longer considered as a
curiosity: but nearly every body has
seen it, and handled it, judging
for themselves some of its physical
properties at least. It is a white
metal of bluish tint. It has a Sp.G.
of 2,5 to 2.7. and melts at above 1,300°F
After Silver, Copper, and Gold it is the
best conductor of heat and electricity.
The properties which are most likely
to introduce Al. into the arts are:
Its lightness. It does not tarnish in
moist atmospheres: nor acted upon by
fumes of sulphur as much as the
other metals. Its easy casting qualities;
extreme malleability; its influence
in various alloys: tensile strength
and elasticity: its electrical, and heat
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Uses:
The time does not seem far distant when the uses of Al. will not be discussed in two or three paragraphs on paper; but like iron, it will be impossible to enumerate its uses. But it will not probably take as long to bring Al. in to common use as it did iron, for the world is in a more progressive state than it was then. The demand for Al. in the year 1891 showed a great increase over the preceeding year; and there is a promise that the year 1892 in the Al. industry; as new applications for the metal are constantly being found such as the replacement of German silver and a high grade brass; in foundries for casting; Cartrige shells for smokeless guns; Canteens for soldiers; buckles and sword scabboards; Cooking utensils harness trimmings; Surgical instruments telegraph and telephone wires, etc. etc. The alloys are also of special importance especially the alloys of Copper, and Al.

E. M. Johnson.

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Uses:
The time does not seem far distant when the uses of Al will not be discussed in two or three paragraphs on paper, but like iron it will be impossible to enumerate its uses. But it will not probably take as long to bring Al in to common use as it did iron, for the world is in a more progressive state than it was then. The demand for Al in the year 1891 showed a great increase over the preceeding year, and there is a promise that the year 1892 in the Al industry as new applications for the metal are constantly being found such as the replacement of German silver and a high grade brass, in foundries for casting, cartrige shells for smokeless guns, canteens for soldiers, buckles and sword scabbards, cooking utensils, harness trimmings, surgical instruments, telegraph and telephone uses, etc. etc. The alloys are also of special importance, especially the alloys of copper and Al.

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